choose in the national interest.

3.5.1 The NHK/MUSE route

If the NHK wideband system is adopted as an international production and program-interchange standard, MUSE will come to the fore as a distribution standard,[14] via cassettes, optical disks, and, in some cases, DBS. Dual-standard NTSC/MUSE receivers will be marketed. Profits will come first to manufacturers, renters, and sellers of receivers and other equipment as well as software. If the receiver population becomes large enough, DBS may be initiated. More theatrical producers would use HDTV for program production, but this would have little economic effect, except on a few equipment suppliers. There would also be some industrial use, again with little effect. The losers would be terrestrial broadcasters and local cable companies, who would lose audience share. There might be some adverse effect on consumers who rely on free TV, if that is impacted. US manufacturers would be effectively shut out of the market. This scenario describes the likely course of events in the absence of any action by the FCC.

Note that MUSE is not compatible with existing 6-MHz channels or with existing receivers. It is intended to provide a wholly new service. A corollary of this path is that NTSC would become a second-class service, with the more desireable programs reserved for the high-definition service. In his recent keynote speech at ISBT'87, "Future Prospect of Satellite Broadcasting and Hi-Vision," Dr. Yuko Nakamura, Director-General of Engineering of NHK, compares present day television and HDTV to AM and FM radio, respectively. This may well be a suitable solution for Japan, but in the US we have certainly not yet come to this decision. The networks, for example, would have a hard time explaining to their stockholders their intention to go the way of AM radio.

3.5.2 Receiver-compatible enhanced-definition (EDTV) route

American thinking about ATV is dominated by two interrelated problems. One is the danger of losing audience share to improved TV delivered by alternate means. The preferred solution is to compete by means of ATV transmissions that are both receiver-compatible and channel-compatible. Although most concede that it is impossible to reach "true" HDTV quality in a completely compatible manner within a single channel, there is ample evidence that significant improvement is possible. While some of this improvement is possible by receiver modifications only, requiring no government action, most worthwhile improvement requires substantial changes in and/or additions to the transmitted NTSC signal.

An example of a one-channel receiver-compatible system is the recently announced Advanced Compatible TV (ACTV) from the Sarnoff Laboratories, which adds additional information to the normal signal with little degradation of reception on existing receivers. A sophisticated receiver constructs a substantially improved image. Other proposed systems use one

[14]The intimate relationship between the NHK wideband production system and the MUSE distribution system comes from the fact that they use the same scanning standards, cameras, and receivers. MUSE is *intended* as the NHK transmission system, and the NHK system is *intended* as the source and sink (destination) of MUSE signals. If it really did not make much difference which production standard was adopted, I doubt that we would see one particular standard so vigorously pressed on us.

standard NTSC channel, for compatibility, plus a second channel,[15] usually 3 or 6 MHz wide, for enhancement information. The special receiver uses both signals, which may be in either adjacent or noncontiguous channels, to construct the enhanced image. There is no question that some system of this kind could be made to work, given sufficient additional bandwidth.

While such systems seem very attractive, they do have some potential drawbacks. One is that there is little evidence that many viewers will pay a lot of extra money to see the same programs in higher technical picture quality. This would lead to slow growth of the new service. This is especially true of the 6-MHz systems, since there is doubt that the quality increment will be sufficiently large. The 9- and 12-MHz systems have the additional problem that they enshrine the inefficiencies of NTSC, permanently eliminating the possibility of HDTV in 6 MHz, which I believe is a realistic goal.

The second issue is the so-called "chicken-and-egg" problem. In a new service, there is little incentive to buy receivers if there are few programs and there is little incentive to produce programs if there are few receivers. Receiver- and channel-compatibility do not completely solve this problem. Color NTSC, which eventually became highly profitable, actually grew rather slowly even with the investment of about $3 billion (at today's prices) by RCA. Today's thinking is that receiver-compatible EDTV will stimulate viewers' appreciation of and desire for high-quality audio and images, and may therefore serve as a "bridge" to true HDTV, which will require a more radical break with the past.

To follow this path, the bridge system must lead to the final system technologically, as well as from the standpoint of image quality. What is impermissible is to promote an intermediate system and then ask consumers, at a later date, to buy still another receiver. We must not create another compatibility problem by selecting, as a "bridge" system, a technological dead end.

The winners in this approach are traditional broadcasters and the domestic manufacturers who may be interested in developing and marketing receivers and professional equipment. Viewers would also benefit, provided that their investment in improved receivers were protected long enough. The losers are those would benefit from the NHK/MUSE approach.

3.5.3 The bandwidth-efficient channel-compatible route

An alternative approach is make the primary requirement on new systems that they conform to the existing channel configuration. There is much evidence that, starting from a clean slate, it would be possible to design an entirely new television system with quality much higher than NTSC, using just one 6-MHz channel. My personal belief is that this quality level will prove to be higher than MUSE, and perhaps comparable to that of the wideband NHK system. The problem with such systems is that, efficient as they may be, and as desirable as they may be in the long run, they are not displayable on existing receivers.[16] No one is suggesting abandoning the 140 million receivers now in use. Therefore existing receivers would have to be

[15]It is not clear that broadcasters could get more than one channel, except, perhaps, for a limited period of time while they make the transition to a final 1-channel HDTV system. Using more than one channel also raises the question of diversity. To go this route means that we must choose between fewer ATV channels and more NTSC channels.

[16]This is one of the problems with using MUSE for broadcasting.

served by separate transmissions, thus requiring additional channels.[17] American broadcasters are loath to take this approach, as it entails extra capital expenditures. From the producer's point of view, it also diminishes the market for his product, if intended for high definition. The problem with this approach, therefore, is that there seems no practical way to get to the final goal without undue economic hardship along the way.

3.5.4 Bandwidth-efficient systems for cable use.

Cable is in a somewhat more advantageous position than terrestrial broadcasting to make use of noncompatible bandwidth-efficient systems. Cable customers are already paying for their programs, so that it would be possible to factor in the cost of new receivers with the cost of programs. The cable audience is large enough to make manufacturing special receivers for that application very attractive to domestic manufacturers. An advantageous feature of such receivers is that they would also be able to display NTSC transmissions (off-air and from VCR's) with better image quality. Thus, there is no particular obstacle to establishing a 6-MHz bandwidth-efficient ATV service in such a controlled medium.

3.5.5 Two-stage introduction of ATV for terrestrial broadcasting

It appears to be possible to reach the highly desirable goal of channel-compatible HDTV if the right kind of bridge system is chosen. In this scenario, bridge technology, as well as performance, must be a stepping stone to the final system. Such an approach is outlined in Document 4.3. The key element in the system is a "smart," programmable, open-architecture receiver. A receiver of this kind, which could as appropriately be made by a computer company[18] as a consumer-electronics company, is so arranged that it can easily and cheaply adapt itself to receive and decode any of a wide variety of TV signals. These formats would include NTSC as well as many different ATV systems. If both a bridge system and a final high-efficiency system are selected that can be displayed on the same new receivers, consumers can buy them with confidence that they will not soon be made unusable by changes in transmission formats. In addition to its advantages in terms of facilitating a flexible policy for phasing in new TV systems, the smart receiver also maximizes image quality of each format.

In this scenario, a channel-compatible bridge system is introduced and smart receivers are placed on sale at the same time. Consumers can use the new receivers for all purposes, including improved display of NTSC (via terrestrial broadcast as well as cable) and playback from NTSC VCR's. Some EDTV broadcasting is started, viewable on all receivers, and in higher quality on the smart receivers. As the population of smart receivers rises, the public's taste for high quality rises, and people begin to prefer the EDTV programs.

Some years down the line, the statistical evidence of viewer behavior can be reviewed. One possibility is that the status quo can be left as is. Another is that the evidence will show an overwhelming preference for high definition. In such a case, a decision can be made that,

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[17]This is exactly what was done in France and Britain when SECAM and PAL were introduced.

[18]Fortunately, the computer industry is alive and well in the US. There is at least some possibility that interest could be aroused in that industry in a TV receiver having some of the attributes of a personal computer. Note that the receiver market is a good deal larger than the PC market.

several years hence, all broadcasting will be in some high-efficiency system receivable on the smart receivers but not on old NTSC receivers. If deemed appropriate, NTSC broadcasts can be maintained on a few channels for some additional number of years. When the system changeover is made, smart receivers will show an immediate substantial improvement in picture quality. As the years go by and more powerful processing capabilities become available, receivers can be upgraded and picture quality can continue to increase.

There are no losers in this scenario. With an evolutionary plan, manufacturers, broacasters, and consumers all can invest with confidence. Market forces can operate freely and a system can evolve that will be acceptable to all concerned. Foreign manufacturers are not discriminated against, but enterprising American manufacturers can have a fair shot at the market.

3.6 Conclusions and Recommendations

Replies to specific questions in the Notice of Inquiry were given in Document 2. Here we deal with the general topic of the future of television in the US, including some specific items not mentioned in the NOI.

3.6.1 Economic nature of the television problem

Everybody likes beautiful pictures, but NTSC pictures, for all their limitations and defects, are good enough for the purposes for which they are used. The great interest shown in ATV by people in the television industry is almost entirely a commercial interest. If ATV ever takes off, it may well be of great economic importance. If a large demand develops for ATV products, and almost all of that demand is satisfied by imports, the domestic economy will suffer. If a substantial portion of the demand can be filled from domestic sources, a welcome stimulus to the economy may be provided.

It is too late to leave this subject entirely to the marketplace, since the Japanese, with a carefully worked out plan and a large investment in money and resources, have already put in place a specific plan that fits their own economic priorities. Without action on the part of the government, the probable outcome is rather clear. Some may argue that those who now stand to be injured directly, principally the traditional program distributors, had ample warning and did not do enough to protect themselves. However, the reasons for the present predicament are beside the point. The subject is too important to be left solely to the television industry for its resolution. The damage will not be only to the distributors - it will be to most of the TV industry, to the consumer electronics industry, and to the country as a whole.

In my view, the actions to be taken by the United States should have the overall aim of creating a level playing field, within the country, for the development of ATV as dictated by the domestic marketplace. Rather than allowing this marketplace to operate in a totally unconstrained manner, it might be reasonable to establish certain minimum requirements for the resulting system, such as the maintenance of a reasonable amount of "free" programming on inexpensive receivers. It might also be desirable to set some preferred goals, such as excellent picture quality in 6-MHz channels. Action might be taken to minimize the waste of consumer investment by ensuring that existing receivers would continue to be usable for a certain

number of years, and that any new receivers would also be useable for a given period. Since some of these matters depend on answers that are not yet available to certain technological questions, what regulation there is should be designed to keep options open as long as possible, and to encourage experimentation as long as it does not cost the public too much money. With these provisos, I recommend the following actions:

3.6.1 NHK and MUSE

The United States should withdraw its support for the adoption of the NHK wideband system as an international standard for program production and interchange. As explained above, MUSE and NHK are cousins - we get one with the other. There is no pressing need to adopt any standard at this time. There are very few domestic interests that would be advanced by using MUSE and there are many that would be injured. While we should not discriminate against these systems, we should not encourage them either.

3.6.2 Spectrum allocations

A date should be set, perhaps 2 or 3 years hence, for a decision as to the bandwidth that will be allocated for a final high-definition service. (If one were to guess today, 6 MHz would not be a bad choice; it would be better not to have to guess.) In the intervening period, studies should be carried out as to how much bandwidth is available and how much is needed for some desired quality of service.

3.6.3 Economic impact

A study should be begun, as soon as possible, to assess the economic effect, on the whole country and not just the TV industry, of the shape of a new high-quality TV system. This study should enlist the support of a wide spectrum of talent from government, industry, labor, academia, and the public.

3.6.4 Receiver compatibility

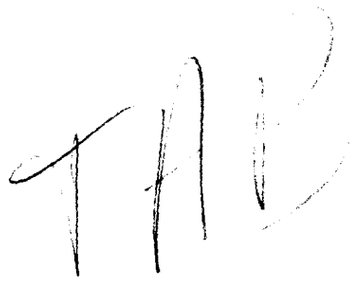
Consideration should be given to legislation setting forth compatibility requirements for ATV receivers sold in the US. No sales should be permitted in advance of promulgating such laws. The purpose would be to ensure that no *de facto* standard develops as a result of the sale of a relatively small number of special-purpose receivers, such as those to be used with MUSE recorded material. The import of MUSE and NHK equipment should not be otherwise regulated. It will take some study to decide on the precise compatibility requirements. They could be in line with the description given above concerning the "smart" receiver.

3.6.5 A period of experimentation

With the public protected by the receiver compatibility regulations, a period of time should be set aside during which experimental transmissions in a wide variety of systems should be encouraged. It would be hoped that within the 2-3 year period mentioned, the bandwidth could be agreed on, and within another 2 or 3 years, the actual system could be chosen. It would have two stages - a first, NTSC receiver-compatible EDTV stage and a second, high-efficiency HDTV stage.

3.6.6 A period of use of EDTV systems

When the EDTV system has been in use long enough to measure its acceptance, a decision can be made as to when HDTV transmissions can be started. A further decision can be made as to when, and if, NTSC transmissions are to be halted.



ADVANCED TELEVISION RESEARCH PROGRAM

ATRP is an MIT research program funded by the members of the Center for Advanced Television Studies (CATS). Each member has a 3-year contract with MIT, paying $100,000 per year. The Public Broadcasting System (PBS), which does not make a monetary contribution, acts as a secretariat for CATS. At present the members are US television broadcasters and other companies interested in the TV industry. The program has Justice Department approval under the antitrust laws.

The broad purposes of the program are discussed in the attached CATS press release. The MIT program is overseen by a Steering Committee consisting of senior faculty members. Authorization for specific projects is made by the Steering Committee and is ratified by the CATS Technical Advisory Board, which consists of one representative of each sponsor. The MIT group maintains close contact with the TAB, which meets several times each year, sometimes at MIT. The TAB, in turn, is supervised by the CATS Board of Directors, also consisting of one member from each sponsor. Provision is made for sponsor personnel to spend time at MIT.

The first contract ran for three years from June 1, 1983. The original sponsors were ABC, NBC, Time, Inc. (Home Box Office), PBS, Ampex, Tektronix, RCA, Harris, 3-M, and CBS, of which all but the last three renewed in 1986. Zenith joined on June 1, 1986, and Kodak joined on Jan. 1, 1987. The present sponsors have indicated their desire to add new sponsors, and a number of additional companies have been contacted. The terms on which new sponsors would join the program have not been decided.

Research Program

The program is carried out mainly by faculty and students. The latter have found it very attractive, thus fulfilling one of the program's objectives. Studies are being carried out in fundamentals of TV transmission, optimization of present and future TV systems, three-dimensional signal processing, visual perception, and audience reactions. For the last purpose, an audience research facility has been constructed in a nearby shopping mall. For the on-campus work, the main research facility is based on a VAX 11/785 and associated peripherals, including a 70-mm film scanner, professional video tape recorder, high-speed disk system, special-purpose high-speed signal-processing hardware, and a variety of displays. The system is being upgraded to permit computer simulation of TV systems operating at very high line and frame rates.

For further information:

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June 1987

FOR MORE INFORMATION CONTACT
ED HOROWITZ (212) 512-5300

PRESS RELEASE
JUNE 28, 1985

CENTER FOR ADVANCED TELEVISION STUDIES WORKS TO IMPROVE U.S. TELEVISION TECHNOLOGY

Plans to Investigate Technology for Improving Picture and Sound Quality.

The Center for Advanced Television Studies (CATS) was created by ten U.S. companies committed to expanding the development of television broadcasting technology and to promote and sponsor independent research. The member companies, all involved in some way with television broadcasting, are American Broadcasting Companies, Inc., Ampex Corporation, CBS Inc., Harris Corporation, 3M Company, National Broadcasting Company, Inc., Public Broadcasting Service, RCA Corporation, Tektronix Inc., and Time Inc. This new group will contract with independent academic institutions to conduct consumer and technological research on ways in which television systems in the U.S. can be improved and made more effective. Projects will focus on ways of increasing the efficiency of TV signal transmission and of enhancing picture and sound quality for optimum viewer satisfaction. Results of all research projects will be published and shared among Center members and other interested U.S. companies.

The first academic institution with which CATS has contracted is MIT. MIT has established a television research center called the Advanced Television Research Program (ATRP), designed to serve as a national laboratory for the study and improvement of television science and technology. It is headed by Dr. William F. Schreiber, Professor of Electrical Engineering. For many years his group has been conducting industrially sponsored research in television, facsimile, and graphic arts. The Laserphoto facsimile system, used by the Associated Press to transmit pictures to newspapers, was developed by this group. That was the first practical, low cost, laser facsimile system. ATRP has been awarded a three (3) year contract totalling 2.7 million dollars, and will use these funds to conduct research into television transmission and display.

CATS Chairman Charles Steinberg, Executive Vice President of Ampex, said the new center fills a need for a centralized research facility where U.S. companies can exchange ideas and stimulate independent research activities beyond those already being carried out in their own laboratories. "In many other countries," he said, "facilites for television technology research have been established by broadcasting organizations, typically with government support. But in the United States little effort has been made to rethink and re-design the basic structure of our television transmission system since it was initially designed and approved by the Federal Communications Commission over thirty (30) years ago. The new center will serve

as a resource for such studies, to help the U.S. television industry improve its position of world leadership in TV technology.

Professor Schreiber said "The present broadcast television system has been highly successful, both technically and economically. Evolutionary improvements in cameras, picture tubes and circuitry have brought about better picture quality. However, current technological trends portend changes of a more revolutionary nature which existing systems may well not be able to accommodate. Some of these," he said "are semiconductor technology, high-definition television, digital television, direct broadcasting from satellites (DBS), cable, fiberoptics, and video discs. A significant array of such new products and possibilities make it highly desirable to conduct research in order to understand the implications of the new technology and to lay the groundwork for future television developments." He listed these objectives for ATRP:

1. To develop the theoretical and empirical basis for the improvement of existing TV systems and the design of those of the future, and for the regulatory policies that will shape their use.

2. To motivate students to undertake careers in the television industry.

3. To facilitate the continuing education of scientists and engineers already working in the industry, through work at MIT as visiting scientists or students.

4. To establish a resource center to which problems and proposals can be brought for discussion and detailed study.

"We plan to take a very fundamental view of the problem of improved TV systems," he said. "If we really want greatly improved pictures, we have to learn to deliver the information more efficiently. Otherwise the channel capacity requirements become excessive and uneconomical. This involves more sophisticated signal processing, both at the transmitter and receiver, processing that is expected to become practical as prices of semiconductor components continue to fall. We hope that U.S. industry will develop a leadership role in applying this new technology to TV equipment."

An important component of the research program at MIT will be audience research. The ATRP's initial effort under the funding provided by CATS will be to investigate both the perceptual and technological basis for improved TV systems.

Steinberg said the center and its proposed activities have been favorably reviewed by the Department of Justice under the departments business review procedures.

From the News Office
Massachusetts Institute of Technology
Cambridge, Massachusetts 02139
Telephone: (617) 253-2701

October 18, 1983

FOR IMMEDIATE RELEASE

Contact: Charles H. Ball

M.I.T. ESTABLISHES TV RESEARCH CENTER

A television research center--designed to serve as a national laboratory for the study and improvement of television technology--has been formed at the Massachusetts Institute of Technology.

The center, called the Advanced Television Research Program (ATRP), is headed by Dr. William F. Schreiber, professor of electrical engineering, whose research group developed a Laserphoto fascimile transmission system for the Associated Press that was the first practical system of its kind.

Oversight for the program will be provided by a steering committee of senior faculty members.

ATRP has been awarded three-year contracts, totalling more than $2.5 million, by members of the Center for Advanced Television Studies, a group of 10 companies recently formed to promote and sponsor independent television research.

The establishment of the M.I.T. center, which will concentrate on research into television transmission and display, was announced by M.I.T. President Paul E. Gray. He termed the research effort "a prime example of a fruitful cooperation between academia and industry, through which the unique capabilities of the university can improve the industrial performance of the nation."

Professor Schreiber said a "significant array of new developments and possibilities" make it imperative to have a research program "in order to understand the implications of the new technology and to lay the groundwork for future TV developments."

"Most other industrial countries already have large television laboratories, centrally financed, which conduct on-going programs of development as well as research," he said.

"These laboratories feed a steady stream of useful results to industry, and provide the knowledge base for national and international regulatory policy," he continued. "The lack of such an organization in the United States is detrimental to the national interest and to the health of the broadcasting and equipment manufacturing industries."

Professor Schreiber listed these objectives for ATRP:

--To develop the theoretical and empirical basis for the improvement of existing and the design of future television systems, and for the regulatory policies that will shape their use.

--To motivate students to undertake careers in the television industry.

--To facilitate the continuing education of scientists and engineers already working in the industry, through work at M.I.T. as visiting scientists or students.

--To establish a resource center to which problems and proposals can be brought for discussion and detailed study.

Professor Schreiber said that the present broadcast television system, designed nearly 30 years ago, has been highly successful technically and economically. Evolutionary improvements in cameras, picture tubes and circuitry have brought about better picture quality,

and the video tape recorder has provided flexibility in programming. Additionally, cable is adding a new dimension to program distribution.

"Current technological trends, however, portend changes of a more revolutionary nature, which the existing system may well not be able to accommodate," he said.

Some of these developments, he said, are semiconductor technology, high definition television, digital television, direct broadcasting from satellites, cable and fiberoptics, and video discs.

"We plan to take a very fundamental view of the problem of improved TV systems," he said. "The Japanese have made major contributions, particularly in the development of better camera and display tubes. Their proposed transmission system, however, is in most respects a scaled up version of the present system. Although the image quality is quite high, a very wide transmission channel is required. Other recently-demonstrated systems make use of modern semiconductor technology, particularly in the receiver, to give somewhat improved images than at present, but with considerably less increase of channel capacity.

"If we really want substantially improved pictures, and ultimately we're talking about theater quality," he continued, "we have to learn to deliver the information more effectively. Because if we don't, the channel band width requirements become excessive and uneconomical. We have to define more precisely what the basic information transmission problem is, and on that basis, come up with proposals for more efficient systems. This will involve, in addition to the transmission aspect, all the other components, including the camera and display device."

"There's also an important question of how an improved TV system might be brought to market--will people be willing to pay for the improvements, and so forth," he added.

An important component of the research program at M.I.T. will be audience research, he said, conducted by Professor W. Russell Neuman in the M.I.T. Research Program on Communications Policy and the Department of Political Science.

The M.I.T. group's initial effort, under the funding provided by the Center for Advanced Television Studies, will be to investigate the technological and perceptual basis for improved TV systems. In addition, new systems concepts will be explored and economic tradeoffs established.

The member companies sponsoring the research are: American Broadcasting Company, Inc.; Ampex Corporation; Columbia Broadcasting Systems, Inc.; Harris Corporation; Home Box Office, Inc.; Public Broadcasting Service; National Broadcasting Company, Inc.; RCA Corporation; Tektronix, Inc.; and 3M Company.

--END--

CHB/10/18/83

Department of Justice

John J. Wood
M.I.T. Rm. 32-402
SEP 29 1983

FOR IMMEDIATE RELEASE
THURSDAY, SEPTEMBER 22, 1983

AT
202-633-2016

The Department of Justice announced today that it will not challenge a proposed Center for Advanced Television Studies or the participation of its members in the anticipated activities of the center.

The center is being formed to promote and sponsor basic research by independent experts into television sciences.

The Justice Department's position was contained in a letter from William F. Baxter, Assistant Attorney General in charge of the Antitrust Division, to counsel for the center.

The center had asked the Department for a business review letter stating the Department's enforcement intention if the center carried out its proposal.

Membership in the center will be open to any business, government, or private organization that is actively engaged in research and development in television broadcast science and whose ultimate parent is domiciled in the United States.

The current members are: American Broadcasting Companies, Inc.; AMPEX Corporation; CBS, Inc.; Harris Corporation; Home Box Office, Inc.; National Broadcasting Company, Inc.; Public Broadcasting Service; RCA Corporation; Tektronix Corporation, and 3M Company.

The first research project is to be performed by the Massachusetts Institute of Technology.

The purpose of the center is to promote exclusively basic, as opposed to applied, research in sophisticated television sciences.

The research will focus on the definition of the ideal television transmission system and on the technological and economic trade-offs to be made in developing and implementing such a system.

The research will not be oriented toward improvement or development of commercial products; no prototype equipment or products will be developed.

Baxter said that the Justice Department has no present intention of challenging the formation of the center or the participation of its members in the center's anticipated activities under the antitrust laws.

He said that although a joint venture consisting of firms controlling a substantial percentage of a relevant market frequently can be anticompetitive, the basic nature of the research and the relationships among the member firms and between the firms and MIT indicate that the formation and anticipated activities of the center are unlikely to have any anticompetitive consequences.

Baxter added, however, that the Department remains free to bring a future enforcement action if the parties' conduct later proves to be anticompetitive in purpose or effect.

Under the Department's business review procedure, an organization may submit a proposed activity to the Antitrust

Division and receive a statement as to whether the Division would challenge that action under the antitrust laws.

A file containing the business review request and the Department's response is available to the public and may be examined in the Legal Procedure Unit, Antitrust Division, Room 7416, Department of Justice, Washington, D.C. 20530. After a 30-day waiting period, the documents supporting the business review will be added to the file.

# # # #

Lab Report

Studying the Effects of New Communications Technologies: The Audience Research Facility

From the consumer's standpoint, few fields have advanced more dramatically in recent years than communications technology. Video cassette recorders, high-fidelity television, video and audio discs, and home computers are just a few of the developments that are adding new dimensions to our ability to transmit, store, manipulate, and display sounds and images of all kinds.

The lab functions primarily as a field testing site for prototype communication technologies and for basic scientific research on communications effects.

The Audience Research Facility (ARF) is a new MIT laboratory dedicated to the study of audience responses to developments in audio and video technologies. The facility is located off campus in the Liberty Tree Mall in Danvers, Massachusetts on Boston's north shore. It began operation in 1985. The lab functions primarily as a field testing site for prototype communication technologies and for basic scientific research on communications effects.

Audience Research is an academic research group funded primarily by corporate sponsors in the communication industry. The research, by its nature, is interdisciplinary and employs survey, experimental, human factors, and marketing research techniques to investigate fundamental questions about the nature of new communications technologies. Among the current sponsors are the Advanced Television Research Program (ATRP), the Future of the Mass Audience Project, Polaroid, and GTE.

ATRP is a television research center at MIT's Media Laboratory designated by the industry to serve as a national laboratory for the study and improvement of television systems. ATRP's initial effort is to conduct basic research on the technological and perceptual basis for improved TV transmission and display. This work is intended to lay the groundwork for a new generation of high resolution television equipment. Industry participants in this research include: ABC, Ampex Corporation, CBS, Harris Corporation, Home Box Office, NBC, the Public Broadcasting Service, RCA Corporation, Tektronix, and the 3M Company.

Photo: Lampe

Professor W. Russell Neuman, Director of the Audience Research Facility.

MIT's Future of the Mass Audience Project is a consortium of communications companies studying the interaction of new media technologies, changing patterns of audience demand, and the long-term economic impact of changing patterns of competition in the industry. A particular concern of this project is the potential shift from large-audience broadcast media to a pattern of special-interest media such as specialized cable channels, videotex and low-power television. The corporate participants in the project include: Time, Inc., Warner Communications, CBS, The New York Times Company, The Washington Post Company, ABC, and NBC.

GTE and Polaroid Corporation are sponsoring research on the use of new visual display, telecommunication, and interactive technologies in the home. At one time, mass communications meant simply public broadcast communication in a one-to-many format, and telecommunications referred to private one-to-one conversations. The digital revolution has changed that pattern dramatically. A series of research studies have been designed on the convergence of mass and personalized communications systems.

RESEARCH AGENDA

The research at ARF focuses on the interaction of technology, content and audience. A fundamental hypothesis underlying the work is that the cognitive and effective impact of mediated messages will vary with the (1) mode of communication, (2) display characteristics of the medium, and (3) user-control characteristics of the medium. Current studies analyze how these effects vary depending on the background characteristics and the task orientation of the media users and the type of communication content involved. Below is a list of the principal issues under study.

• ***The Display.*** Recent developments in broadcast and telecommunications technology offer the user new choices in accessing information and entertainment. These include high-resolution and large-screen video, videotex, high-quality audio and a variety of home printers for

(continued on next page)

Lab Report

electronically delivered text and graphics. How important are these improvements? Do people notice any differences in the technologies? How might these new media be used?

• ***Control.*** Many new technologies provide the user with increased control over the amount and flow of information. Interactive technologies including home computers, videodiscs, VCRs and two-way cable offer the audience the ability to filter and control this flow and to choose from a much broader variety of sources. Will interactivity lead to changes in long ingrained habits of passive media behavior? Will it change how people accumulate information from the media?

• ***Media-Content.*** Surprisingly little systematic research has been conducted in response to McLuhan's widely publicized question about the effect of the medium on the message. A series of studies has been designed to explore how mode of communication affects the audience's understanding and interpretation of messages.

• ***Market Innovation.*** A number of new media are being introduced and diffused into the marketplace. What types of groups and individuals are most likely to use these new technological options? Do early adopters tend to be typical of the marketplace as a whole? Will some new technologies lead to even greater inequities in access to public information?

• ***Communications Effects.*** There is a long history of social and psychological research on the effects of mass media on audiences. Will the new technologies lead to communication of greater educational, emotional, and persuasive impact? How might these new technologies compare to current ones in terms of their effects on the audience?

Photo: Courtesy ARF

The Audience Research Facility is located in a shopping mall, which makes it possible to recruit relatively representative samples of adult subjects. Studies have shown that 83% of American adults are regular mall shoppers.

CURRENT RESEARCH PROJECTS

Because of the flexibility built into the laboratory, a wide variety of technological and behavioral research studies are conducted. The current projects include the following:

MIT's Future of the Mass Audience Project is a consortium of communications companies studying the interaction of new media technologies, changing patterns of audience demand, and the long-term economic impact of changing patterns of competition in the industry.

• ***The Television Display Study.*** This series of studies examines individuals' uses of and preferences for various display characteristics of new television technologies. These characteristics include: graphic resolution, audio quality, and screen size.

• ***Electronic Publishing.*** A series of studies is now under way to examine people's preferences for a variety of home based information services. Currently, prototype versions of transactional, information, and entertainment services are being developed for use in these studies. Two-way and one-way versions including full motion video, video stills, and print will be compared.

• ***Interactive Television.*** Another series of studies examines the influence of user control and interactive structure on information and entertainment television.

(continued on next page)

Lab Report

These studies will compare learning and emotional involvement for interactive and observational versions of traditional television content.

• ***The News Study.*** The influence of the media on the audience's perception and learning from news is being explored. The studies focus on the effects of modality differences (audio, text, video) and interactive structure on learning from current and future news services.

• ***The Future of Hard Copy.*** This project focuses on the future of imaging in the home. The convergence and interaction of electronic and photographic technologies with characteristics of the audience is being explored. This complements ARF's research on visual discrimination of video images.

ARF also provides an opportunity for students to conduct their own research projects. The Ithiel de Sola Pool Research Award has been established to promote this goal. The first recipients of the award are examining the effects of different formats on political campaign communications.

THE FACILITY

The 1,200 square-foot facility includes four research areas, a reception area and a control room. A specially designed audio room adjoins the control room and is suitable for audio and acoustic research. A simulated living room is designed to replicate home media-use patterns. A larger viewing room with video and film projection equipment is designed for group viewing studies and can be divided up into smaller experimental areas. The audio room and living room areas are also used for focus group and depth interview studies.

The location of the facility at the Liberty Tree Mall makes possible the recruitment of a relatively representative sample of adult subjects. Studies indicate that 83 percent of American adults are regular mall shoppers. Liberty Tree is a primary mall for Essex County north of Boston which includes urban-industrial, suburban, and semi-rural communities and an ethnically and socioeconomically diverse population. The mall has 118 stores and a daily traffic of 25,000 shoppers.

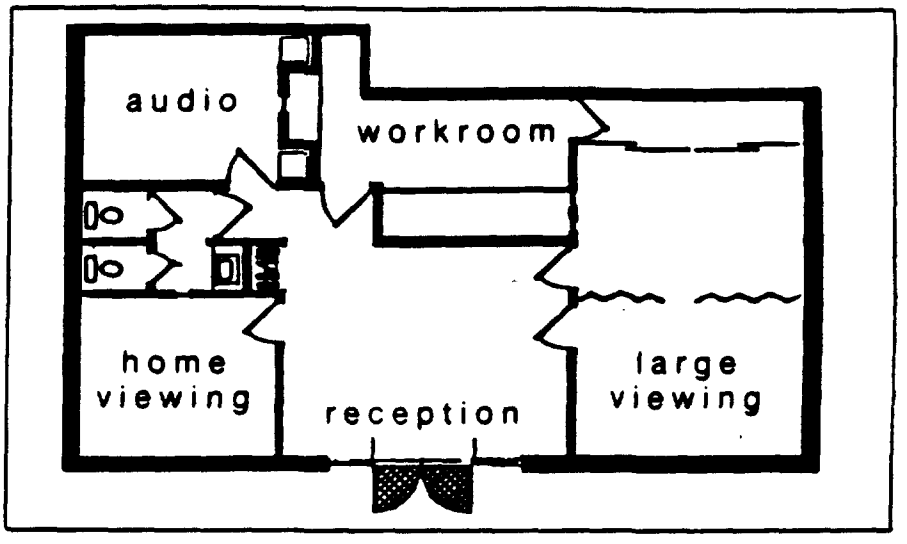


Photo: Courtesy ARF

The 1200 square-foot facility includes a simulated living room for studying home media use patterns, a special audio room, and a large viewing room with video and film projection equipment for group viewing studies, in addition to a control room and a reception area.

Lab Report

Center for Television Studies

Nearly 30 years ago, engineers laid the groundwork for today's tremendously successful broadcast television system in the United States. Over the years, gradual improvements in circuit design, picture tubes, and cameras have produced steadily improved pictures, while the videotape recorder has offered more flexibility in programming. And cable television is now providing more options for program distribution.

All of these developments, however, have been refinements and enhancements of the original technological concepts. Recent technological advances in areas ranging from very large scale integrated circuits to video discs may well provide opportunities for more revolutionary changes.

To study the implications of the new technologies and to set the stage for future developments, a television research center — designed to serve as a national laboratory for the study and improvement of television technology — has just been formed at MIT. This center taps the expertise of faculty, staff, and students in areas ranging from electrical engineering to political science.

The Advanced Television Research Program (ATRP), is headed by Dr. William F. Schreiber, professor of electrical engineering, whose research group developed the Laserphoto facsimile transmission system for the Associated Press that was the first practical system of its kind.

ATRP has been awarded three-year contracts, totaling more than $2.5 million, by members of the Center for Advanced Television Studies, a group of 10 companies recently formed to promote and sponsor independent television research. The member companies are: American Broadcasting Company, Inc.; Ampex Corporation; Columbia Broadcasting Systems, Inc.; Harris Corporation; Home Box Office, Inc.; Public Broadcasting Service; National Broadcasting Company, Inc.; RCA Corporation; Tektronix, Inc.; and 3M Company.

According to Professor Schreiber, most other industrial countries already have large television laboratories, centrally financed, which conduct ongoing programs of development as well as research. These laboratories ed a steady stream of useful results to industry, and provide the knowledge base for national and international regulatory policy. Professor Schreiber maintains that the lack of such an organization in the United States is detrimental to the national interest and to the health of the broadcasting and equipment manufacturing industries.

Overall, ATRP has the following objectives:

- To develop the theoretical and empirical basis for the improvement of existing television systems and the design of future ones, as well as for the regulatory policies that will shape their use.
- To motivate students to undertake careers in the television industry.
- To facilitate the continuing education of scientists and engineers already working in the industry, through work at MIT as visiting scientists or students.
- To establish a resource center to which problems and proposals can be brought for discussion and detailed study.

Professor William F. Schreiber, head of MIT's new Center for Television Studies.

The MIT group's initial effort, under funding provided by the Center for Advanced Television Studies, will be to investigate the technological and perceptual basis for improved TV systems. In addition, new systems concepts will be explored and economic tradeoffs established. Some of the technological developments which may contribute changes are semiconductor technology, high definition television, digital television, direct broadcasting from satellites, cable and fiberoptics, and video discs.

In order to take advantage of these developments, the Center plans to take a fundamental view of the problem of improved TV systems. Schreiber suspects that incorporating new technologies will require a re-thinking of the established standards in the industry. While the Japanese have made major contributions, particularly in the development of better camera and display tubes, their proposed transmission system, Schreiber insists, is in most respects a scaled-up version of the present system. Although the image quality is high, it requires a very wide transmission channel to obtain that quality.

Other recently demonstrated systems, however, make use of modern semiconductor technology, particularly in the receiver, to give somewhat improved images than at present, but with considerably less increase of channel capacity. Today's more compact circuits make it practical to do extensive signal processing in the television set to boost picture quality. A key element could be a "frame store," for example, which effectively decouples the transmitted signal from the displayed picture. The stored frames can be processed to remove the effects of scan lines and the "flicker" characteristic of today's televisions.

"If we really want substantially improved pictures, and ultimately we're talking about theater quality, we have to learn to deliver the information more effectively," Schreiber says. If we don't, he explains, the channel band width requirements become excessive and uneconomical. We therefore have to define more precisely what the basic information transmission problem is, and on that basis, come up with proposals for more efficient systems. This will involve coordinating all the developments in everything from the transmission components to the camera and display device.

An important component of the research program at MIT will also be audience research, conducted by Professor W. Russell Neuman in the MIT Research Program on Communications Policy and the Department of Political Science. Professor Neuman has long studied questions on the social impact of mass media in the electronic age.

Other research questions to be considered include how an improved TV system might be brought to market. No one yet knows for example, how much people will be willing to pay for the improvements.

Oversight for the program will be provided by an interdisciplinary steering committee of senior faculty members. Professor Schreiber is the chairman and John E. Ward, on the research staff of the Laboratory for Information and Decision Systems, is secretary. The other members are former MIT President and Institute Professor Jerome B. Wiesner, Professors Ithiel de Sola Pool of the Political Science Department, Professors Richard B. Adler and Jonathan Allen of the Department of Electrical Engineering and Computer Science, and Professor Andrew B. Lippman of the Department of Architecture.

For more information on the Center for Television Studies, circle number 61 on the Publications order card.

November 13, 1987 ATRP-T-77

Performance of Proposed EDTV and HDTV Systems

Executive Summary

In this note, the performance of the principal schemes that have been proposed for Advanced Television Systems is analyzed. The results of the analysis are tabulated and displayed graphically, with additional comments. Performance parameters included are spatial resolution in fixed and moving areas for both luminance and chrominance, bandwidth requirements, degree of compatibility, probable performance under multipath and low SNR conditions, and receiver complexity. In some cases specific advantages and disadvantages are pointed out.

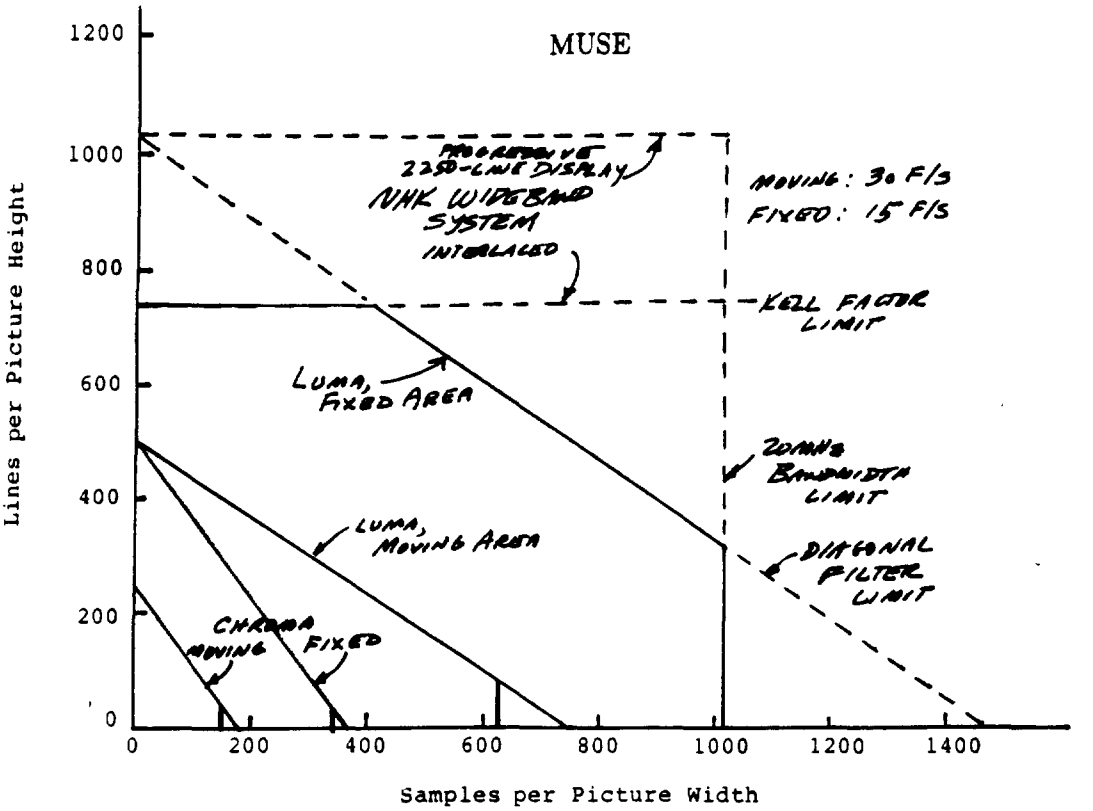
Basic Assumptions

In the following analysis, we have assumed that the resolution is limited primarily by the scanning standards and the channel bandwidth, and in some cases by the amplifier bandwidth. Camera resolution is not taken into account. The actual resolution achieved will be less than shown, with the reduction being larger for the higher-resolution systems. The vertical resolution in lines/picture height (lph) is set equal to the number of active lines for systems that use double the number of lines, progressively scanned, in the display as compared with the channel signal. Where the display is at the same standards as the channel, the resolution is assumed to be .7 times this figure, and if the display is progressively scanned with the same number of lines or interlaced with twice the number of lines, the ratio is taken to be .85. The horizontal resolution in pels/picture width (ppw) is taken to be twice the bandwidth times the active line time. All frequency-plane figures are to the same scale.

There is some uncertainty in the calculations, because none of the systems is decribed precisely and completely in the literature. In the case of systems that use diagonal sampling, there is also some uncertainty in the combined effect of the diagonal filtering, subsampling, and subsequent transmission through a low-pass filter whose bandwidth is less than the Nyquist bandwidth for the given sampling rate. No large errors are believed to exist in the charts, however.

Glendale (Del Rey) System (not shown)

This system claims an area resolution of three times that of NTSC. Starting with a signal of this high resolution, subsampling produces a signal (with aliasing) that has NTSC scanning standards and can be viewed on a standard receiver. The special receiver uses a frame store to reconstruct the high resolution picture. As described in the paper, the EDTV receiver is exactly like MUSE, but without even the minimal motion adaptation of the latter. The compatible signal shows the aliasing as 10 Hz flicker around sharp edges. The flicker can be reduced by a certain amount of prefiltering, which would reduce the SNR of the EDTV image. Moving objects would expect to be blurred by the subsampling, as in MUSE, but probably to a larger degree because of the lack of motion-adaptive interpolation.



Wideband NHK System

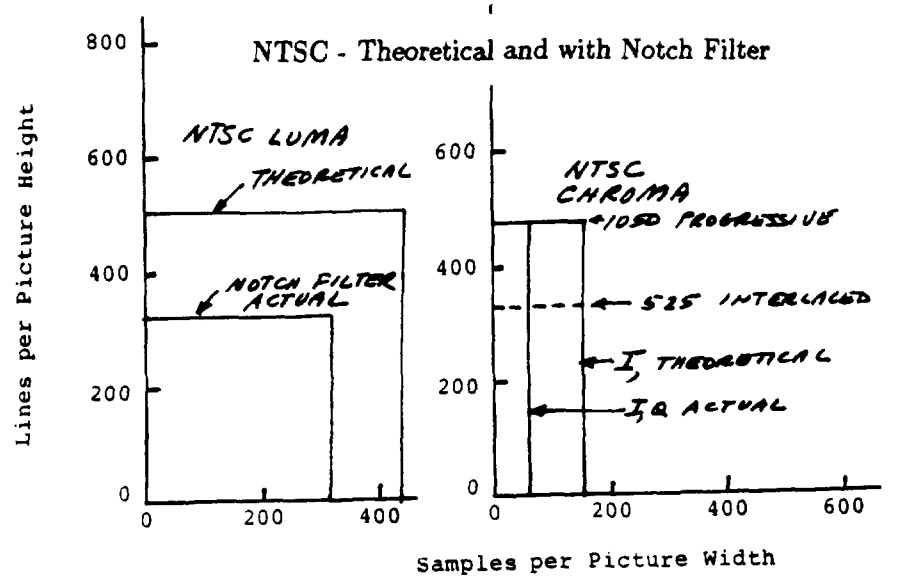
Using an interlaced display with 1040 active lines and with 20 MHz for luma and 5.5 and 7 MHz for C2 and C1, respectively, and assuming 15% retrace time, this system has 1007 ppw luma, with 353 ppw C1 and 277 ppw C2. Assuming 1040 active lines, the interlaced display would be expected to give 728 lph for both luma and chroma. Actually, the *limiting* resolution normally observed is about 800 lines, which is consistent with these calculations.

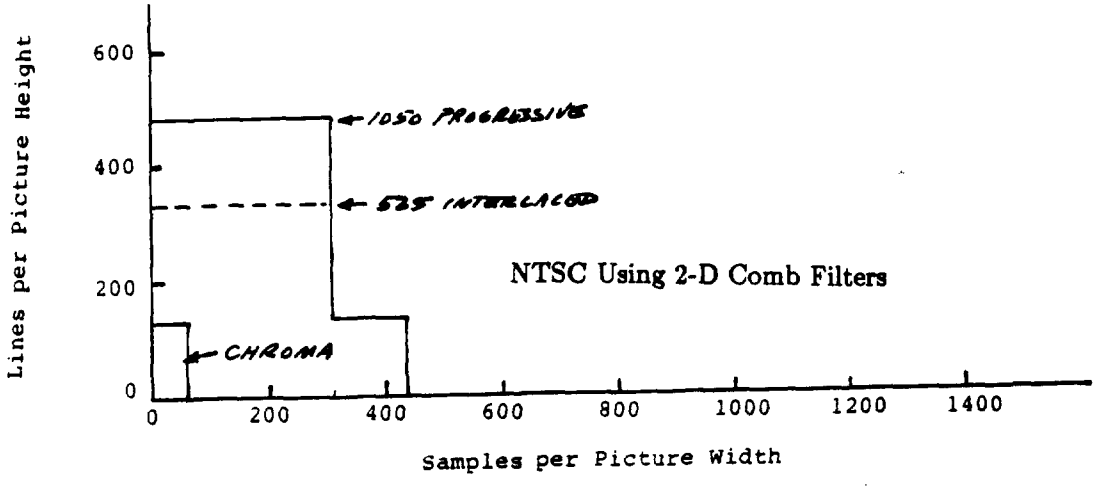
MUSE

MUSE starts with an idealized 1125-line, 30/60 NHK signal, which is processed with a diamond-shaped prefilter and then sampled at 64.8 MHz, for 1920 samples/line, of which only 12 are used for sync. The vertical interval also is eliminated. On each line, 94x4 = 376 samples are chroma and 374x4 = 1496 are luma. There are 1040 active luma lines and 520 each for C1 and C2, each frame. Audio and data are transmitted in 38 lines per field. Alternate samples are discarded in an offset pattern, and the remaining samples are used alternately on successive frames. Thus the sampling rate is 16.2 MHz, giving 94 chroma and 374 luma samples per transmitted line. In the receiver, the signal is reconstituted from the samples using intrafield spatial interpolation in moving areas and temporal interpolation in stationary areas.

Even in stationary areas, MUSE has only one-half the picture elements as the idealized NHK system from which it is derived. I believe that the reason it looks almost as good as the wideband system is that the camera resolution is rather low. The horizontal resolution cannot be more than the equivalent of 20 MHz bandwidth in the wideband system, or about 1007 ppw. In the moving areas, the blurring caused by spatial interpolation can readily be seen.

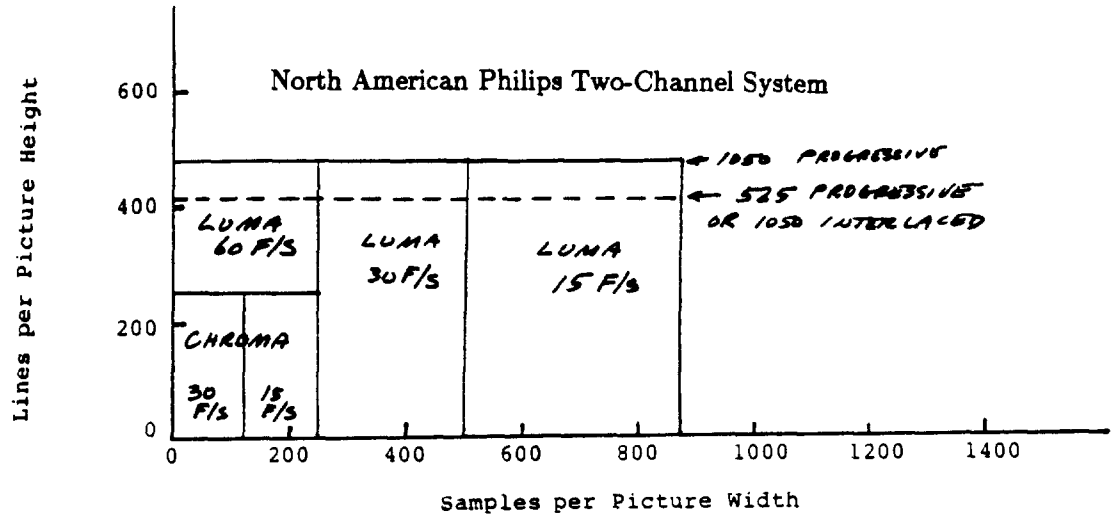
Since successive signal samples are 4 samples apart in the original image, MUSE is highly susceptible to loss of horizontal resolution due to multipath transmission. At the recent Ottawa meeting Dr. Ninomiya stated that MUSE "was not optimized for cable transmission." The Washington demos held this last winter showed that MUSE was also not suitable for terrestrial transmission.





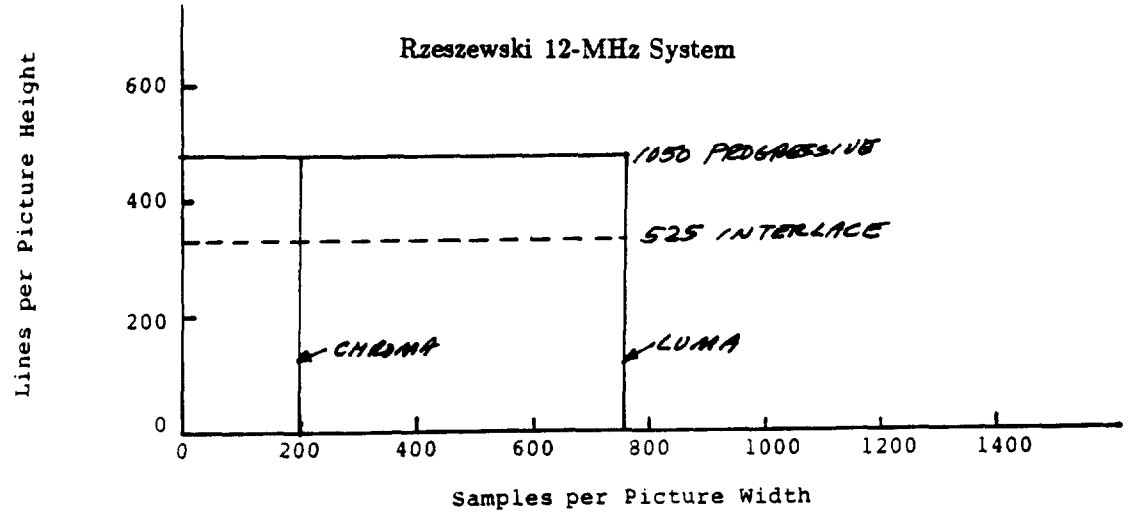
NTSC

The theoretical resolution of NTSC luminance is 480 lph and 440 ppw. The theoretical chroma resolution is 480 lph, 63 ppw for Q, and 158 ppw for I. There are many possible receiver configurations for NTSC. No existing receivers appear to make use of the wider I bandwidth. A notch-filter receiver without upconversion has substantially reduced resolution in all directions, but still shows cross color. With 2-d pre- and postfiltering to eliminate cross effects, and with a 1050-line progressive display, the vertical luma resolution at low horizontal frequencies becomes 480 lph. The price is a reduction of vertical chroma resolution and of vertical luma resolution at high horizontal frequencies to only 120 lph.



The North American Philips System

This is a backward-compatible EDTV system using an unmodified NTSC signal in one channel plus an augmentation signal in a second channel. The latter is used to increase horizontal resolution, add side panels and digital audio, and improve the vertical rendition by cancelling some interlace errors. The EDTV output is to be viewed on a 525-line progressive display, although a 1050 display could be used instead. This system has been demonstrated in part.



Rzeszewski (AT&T) System

This system doubles the horizontal resolution of luminance and chrominance by the use of a second, contiguous, channel. Vertical resolution improvement and elimination of luma-chroma crosstalk is proposed using well known methods that do not involve adding extra signals. The system has not been simulated.